COMMUNITIES' STRUCTURE AND HEAVY METALS CONTENT OF THE UNIONIDAE (MOLLUSCA, BIVALVIA) FROM THE DANUBE DELTA BIOSPHERE RESERVE

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Abstract

This paper presents the Unionidae assemblages from some areas of the Danube Delta Biosphere Reserve. Among the 6 species of naiads, the most abundant is *Anodonta cygnaea* L. 1758, and the most rare is *Unio crassus* Philipsson, 1758. The adventive species *Anodonta woodiana* Lea, 1834 is in full process of expansion, being a potential danger for the autochthonous species. The contents of some heavy metals in water, sediments and bivalves (both in soft body and shells) are analysed. Although the mostly researched areas from the DDBR are in pristine ecological conditions, the hydrotechnical works and pollution represent serious dangers for the future. In many cases the most hazardous metals are above safety limits for these organisms.

Keywords: Danube Delta, Unionidae, heavy metals, communities

Introduction

The Unionidae from the Danube Delta Biosphere Reserve are represented by 6 species, among them 5 are native (namely *Unio pictorum* L. 1758, *U. tumidus* Philipsson, 1788, *U. crassus* Philipsson, 1788, *Anodonta cygnaea* L. 1758 and *Pseudanodonta complanata* Rossmässler, 1835) and one (*Anodonta woodiana* Lea, 1834) is adventive. Once, another unionacean species was considered to be present in the DDBR and other areas of the Danube, namely *Colletopterum letourneuxi* Bourguignat 1881 (according to Grossu, 1962, p. 185, Fig. 94), but the authors of this paper agreed that it is an artificial species, being only a morph of *A. cygnaea.* Even Grossu reconsidered his position, e.g. he did not include this taxon in the catalogue of the molluscs from Romania published in 1993.

The naiads are excellent bioindicators of environmental state and quality, both defined by their populations and assemblages' parameters and by the capacity of bioaccumulation, especially of different xenobiotics. Unionaceans are associated with pristine conditions, i.e. unpolluted water, natural-like habitats, being thus a negative index of pollution. Among all bivalves these are the most affected ones by anthropogenic alteration of the waterways (Burky, 1986). Although the most part of the Danube Delta Biosphere Reserve shelters habitats in good condition, some parts were disturbed because of hydrotechnical works. Channelization straightens and deepens winding waterways, until they become virtual canals. This process is always correlated with density-decreased populations, dispersal alteration, and high mortality rates of juvenile stages. Damming, on the other hand, is associated with parasitism, alteration of oxygen and temperature regimes and siltation.

Heavy metals are among the most dangerous xenobiotics, being responsible in a high degree for the disappearance of unionaceans from some rivers reaches. The most toxic elements are, in descending order: Zn, Cu, Hg and Ag (Fuller, 1974). I. Sîrbu et al. (unpublished data) exposed individuals of *U crassus* to 1 ppm Cu, Ag, Pb, Ni, and Hg. It was pointed out that the respiration rate was reduced to less than 1/10 in the case of Cu and Ag, to 1/3 in the case of Hg, 1/2 in the case of Pb and Ni, compared with the control sample. It was also shown that the regression between oxygen uptake and Log (weight) was altered; especially in the samples exposed to Cu and Ag the highest rates of inhibition were recorded both in juvenile and old stages of life. Higher concentrations lead to the disappearance of unionids, as it happened on long reaches of the Someş, Lăpuş, Tur, Mureş and Bârzava rivers.

This study aims to highlight some characteristics of unionacean communities' structure and of their heavy metals contents in shells and soft body parts, both from the Danube River and Delta.

Research methods

The Danube Delta Biosphere Reserve was intensely studied during a project of biodiversity inventory (1991-1999). During the field trips the freshwater molluscs were studied mainly in the strictly protected areas, but also in the buffer zones and surroundings. Unionids were sampled both manually and with dredges. Individuals were sampled from the Danube River and Delta, in order to analyse their heavy metals content.

Results and discussion

As it is shown in Tab. 1, the most abundant species in the DDBR is *Anodonta cygnaea,* followed by *Unio pictorum* and - in less extent - by *Unio tumidus.* This pattern is common among lowland wetlands. *Unio crassus* is a rare species in DDBR, being constrained by the lack of specific habitats. It is also the single unionacean species included in the official Red List of the reserve (Sîrbu and Sárkány-Kiss, 2000, p. 80 - 81).

Tab. 1. The structure of the Unionidae communities from different lakes and channels of the DDBR

	Unio crassus %	*Unio pictorum* %	*Unio tumidus* %	*Pseudanodonta complanata* %	*Anodonta cygnaea* %	*Anodonta woodiana*	Unionidae No.ind./m^2	Unionidae less than 4-5 years - %	Unionidae less than 1 year - %	Recently dead individuals - %
Lake Merhei			1,72	1,72	96,55		1			40,00
Lake Puiu		10,00		+	90,00		2,5			
Lake Isacova		16,66			83,33		3,5			
Lake Roşu		14,81	24,69	1,23	59,25		15	5,00		
Lake Matiţa		34,71	1,88		43,39		2,5	1,88		30,00
Lake Tătaru		60,71		3,57	35,71		2,8			30,00
Lake Lungu		72,22			27,78		3,6			
Lake Uzlina		55,31	17,02		27,65		7	2,00		
Lake Fortuna		30,58	48,23	1,17	20,00		8,5	4,70		
Lake Razelm		40,00	20,00		60,00	+	?	60	45	
Lake Goloviţa		+	+		+		?	+	+	
Lake Zmeica		+	+	+	+		?	+	+	
Lake Sinoie		+	+		+		?	+	+	
Lake Roşca		66,67			33,33		?	33,33	33,33	33,33
Lake Belciug		13,04		4,36	82,60		?	+		
Lake Rotundu		20,00			80,00		?	20,00		
Lake Babina	+	+				+				
Lake Lumina		+								
Lake Nebunu		+		+	+	+				
Lake Sacalin		+	+	+	+	+				
Channel Dunavăţ		20,83	25,00	8,33	45,83		12	20,00	+	
Channel Lopatna	20,00	60,00	20,00				11	25,00	+	
Channel Tătaru		+	+		+					
Ch. Caraorman		+	+	+						
Branch Chilia		33,33	66,66				?	50,00	+	

The most endangered species among native naiads seems to be *Pseudanodonta complanata*, which encounters low abundance in several areas, but it is widely spread inside the reserve. This species is endangered in most part of the country because of habitat destruction and pollution, while in the DDBR it is still currently sampled. Anyhow, siltation and xenobiotics are serious dangers for this exacting species, even in this reserve.

The adventive species *Anodonta woodiana*, first sampled 5 years ago, is in full process of expansion. In 1996 the species was recorded in the Balta Mare a Brăilei (a sector near the town of Brăila), and in the same year several empty shells from the Danube Delta were sampled (Marius Skolka pers. comm.). The first record of living individuals belonging to *A. woodiana*, was done in 1998 by Orieta Hulea, who had found the species in several pools and channels from the DDBR, namely in the Babina Lake, Cardon Lake south of Popina, and also in the areas of Nebunu, Alb, Meşter and Purcelu lakes. It is remarkable to find this species in the same year in several zones, considering the fact that the Danube Delta has been intensely researched, especially in the last 10 years. In 1999, I. Sîrbu had found one single dead individual in Meleaua Sacalin, south of the point where the Sfântu Gheorghe branch of the Danube flows into the Black Sea. In the shallow water of this place, the most dominant species is *Anodonta cygnaea*, followed by *Unio pictorum*. It is highly likely that *A. woodiana* will develop in the future a large and abundant population in the DDBR, as it does in other places soon after its appearance (Sárkány-Kiss, Sîrbu, Hulea, 2000).

Anyhow, sediments and alluvial accumulation, perturbation of waterflow and pollution are serious threats, fact that is proved by the small proportions of young mussels in most of the researched areas and by high values of recently dead individuals (see Tab. 1).

Regarding heavy metals and other elements content, the highest values are registered in the soft bodies for Ba, followed in descending order by Cu, Ni, Cr, Th, Co, Pb and Zn. In the shells the contents descend in the following order: Sr - Zn - Pb - Ni - Ba - Co - Cu - Cd. Analysing the rate between the contents in the soft body and shells, values higher than 1 are registered for Cu, having the maximums 33,35 in *U. pictorum*, 7 in *U. tumidus* and 6 in *A. cygnaea*, and also for Ba and Cr. In contrast, there are no significant values in the soft body for Zn and Pb, although the sediments are in some cases heavily loaded. Regarding the rate between the contents in the soft body and the upper layer of sediments, the highest values are registered in *U. pictorum* (51,15), and in a less extent in *A. cygnaea* (especially Cr, Co and Ni). *U. tumidus* seems to accumulate in the body less than the other analysed species. Regarding the ratio between shell contents and the upper thin layer of sediments, the highest values are shown by *A. cygnaea* (Co, Pb, Sr). *P. complanata* seems to accumulate especially Sr, Co, Pb, Zn, *U. tumidus* Sr and Co, *U. pictorum* Sr and Zn. It is obvious that in the same conditions different species tend to accumulate in different rates the existing heavy metals. Analysing the most hazardous metals for this species (Tables 2 - 5; Fig. 1 - 6), several patterns could be described. In all species the content of Cu in the soft bodies is higher than in shells. The contents in sediments and soft bodies are directly correlated up to a point, thereafter the rate is reversed.

Table 2. Heavy metals contents in the water of the Danube Delta and Danube River (ppm).

Sampling Site	Layer	Cu	Pb	Zn	Ni	V	Cr	Co	Sr	Cd	Fe	As	Mo
Roşu Lake	Top	*	*	*	2.40	.43	*	*	217	.17	27	*	.95
	Bottom	*	*	*	*	.20	*	.23	207	.06	17	1	*
Matiţa Lake	Top	*	*	*	.85	1	*	*	228	.11	19	*	1.65
	Bottom	6	20	*	1.19	.52	1	.60	227	.05	101	1.4	.38
Merhei Lake	Bottom	*	*	*	2	1	*	*	232	.06	6	1.4	1
Fortuna Lake	Top	2	760	*	2	.46	*	*	200	.08	22	*	.08
	Bottom	2	5.30	*	*	.71	*	*	200	.10	14	1.2	1.6
Meşteru Lake	Top	*	45	*	.42	.99	*	*	222	.18	23	*	1.5
	Bottom	1	*	*	.70	.92	.03	.42	196	2	161	*	*
Danube km 866	Bottom	*	0	*	3	2	.51	0	185	.02	6	0	2
Danube km 911	Bottom	2.30	4	*	3	.86	1	.02	163	.03	104	.9	1.8
Danube km 950	Top	2.10	1	*	2.90	.72	1.30	.73	164	0	66	1.2	.48
	Bottom	5.90	12	*	3	4	.52	.22	154	.09	147	1.2	1.3
Danube km 1044.6	Top	.71	0	*	1.75	.73	.42	.18	186	0	55	0	.88
	Bottom	6.05	.71	*	2	.66	.72	.03	161	.12	*	1.1	2.0

Table 3. Heavy metals in the Danube's Delta and River sediments (ppm)

Sampling Site	layer	Cu	Pb	Zn	Ni	V	Ba	Cr	Co	Sr	Cd	Type of sediment
Roşu Lake	A	*	3	41	12	10	756	20	1	604	6	Medium silt
Matiţa Lake	A	10	10	19	19	48	-	46	5	-	-	Coarse silt
	B	7	9	15	15	48	-	47	6	-	-	Coarse silt
Fortuna Lake	A	50	22	83	47	118	-	104	15	-	-	Fine silt
	B	47	24	81	42	112	-	100	15	-	-	Fine silt
Meşteru Lake	A	180	24	149	37	100	1242	120	10	156	46	Coarse clay
	B	44	16.5	141	39	110	972	117	9	156	20	Very fine silt
Danube km 866	A	897	67	0	98	118	960	168	21	144	22	Fine silt
Danube km 950	A	72	48	91	69	101	900	159	17	150	26	Medium silt
	B	36	46	103	39	130	1072	157	20	149	20	Medium silt
Danube km 1040	A	13	17	46	46	43	-	89	8	-	-	Coarse sand
Danube km 1044.6	A	1090	30	24	26	100	794	63	13	116	21	Medium silt
	B	1900	27	0	19	75	721	40	17	108	25	Medium silt

*Notes on used codes: * = below detection limit; - = no data available; in the column of "layer" code A means the upper thin layer, and B codifies the lower thick layer.*

Table 4. Heavy metals content in the soft bodies of the Unionidae (in ppm)

Sampling point	Species	Cu	Pb	Zn	Ni	V	Ba	Zr	Cr	Co	Th
Roşu Lake	Anodonta cygnaea	135.2	0	0	18	0	1296.3	.226	28.3	1.13	0
Merhei Lake	*Anodonta cygnaea*	0	0	0	15	0	609	0	34	1	0
Fortuna Lake	*Anodonta cygnaea*	41	0	0	17	0	1583	1	32	2	0
Meşteru Lake	*Unio pictorum*	0	0	0	28	0	2316	.75	33	3	0
Danube km 866	*Unio tumidus*	0	2	0	25	0	3059	0	40	2	80
Danube km 911	*Unio tumidus*	1346	2	0	24	0	1864	1	50	4	14
Danube km 950	*Unio pictorum*	1205	4	0	29	2	2656	2	47	6	49
Danube km 1030	*Anodonta cygnaea*	47	0	0	12	0	1597	0	29	1	37
	Unio tumidus	162	79	563	43	0	5736	0	7.6	6	176
Danube km 1040	*Unio pictorum*	665	11	0	29	0	2017	1	62	3	33
Danube km 1044.6	*Unio pictorum*	147	8	0	23	0	2041	0	31	3	50

Table 5. **Heavy metals content in mussel shells (ppm).**

Sampling point	Species	Cu	Pb	Zn	Ni	V	Ba	Zr	Cr	Co	Sr	Cd
Roşu Lake	*Anodonta cygnaea*	24	51	77	63	3	50	0	21	36	1000	9
Meşteru Lake	*Pseudanodonta complanata*	31	67	367	67	0	20	30	23	38	800	10
	Anodonta cygnaea	28	63	97	75	5	120	0	24	38	1200	10
	Unio pictorum	28	70	784	76	5	80	0	22	36	900	10
Danube km 866	*Unio tumidus*	30	60	108	71	7	75	0	26	33	500	8
Danube km 1030	*Unio tumidus*	21	67	92	71	5	25	0	21	32	450	10
	Anodonta cygnaea	22	56	86	69	5	25	0	23	33	250	9
Danube km 1040	*Unio pictorum*	20	70	99	68	0	40	0	23	35	700	10
Danube km 1044.6	*Unio pictorum*	27	77	82	70	3	20	0	21	40	450	8
	Anodonta cygnaea	31	56	88	67	7	140	25	20	37	800	9

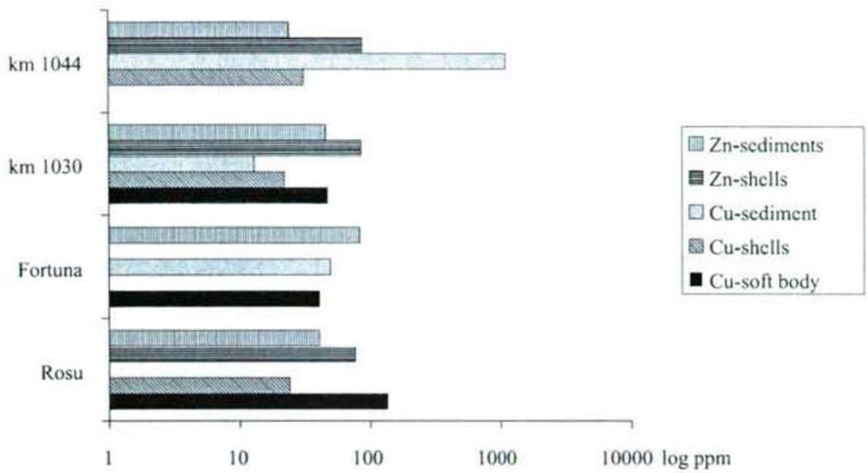

Fig. 1. Content of Cu and Zn in the soft bodies and in shells of *Anodonta cygnaea* and in the upper thin layer of the sediments in Roşu and Fortuna Lakes and in the Danube km 1030 and km 1044.6.

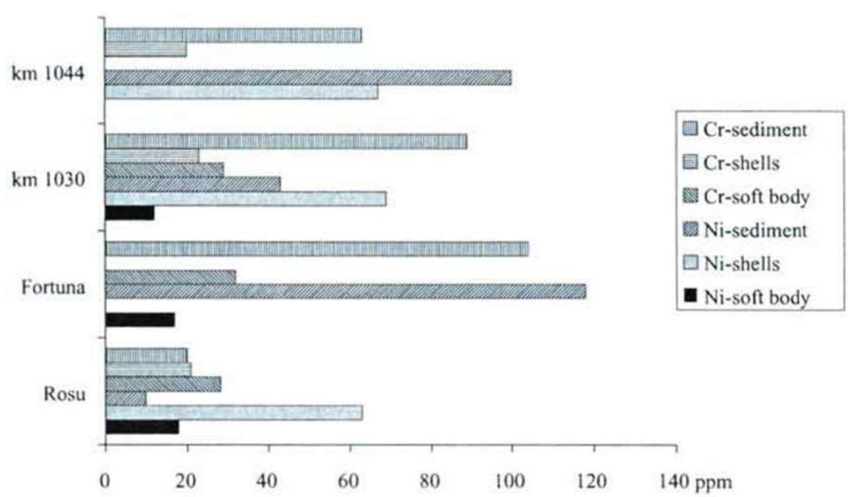

Fig. 2. Content of Ni and Cr in the soft body and in shells of Anodonta *cygnaea* and in the upper thin layer of the sediments in Roşu and Fortuna Lakes and in the Danube km 1030 and km 1044.6.

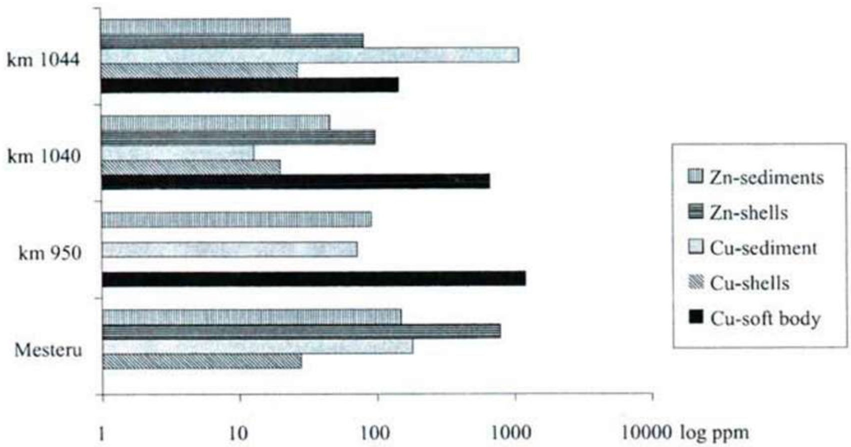

Fig. 3. Content of Cu and Zn in the soft bodies and shells of *Unio pictorum*, and in the upper thin layer of the sediments in Meşteru Lake and in the Danube River km 950, km 1040 and km 1044.6.

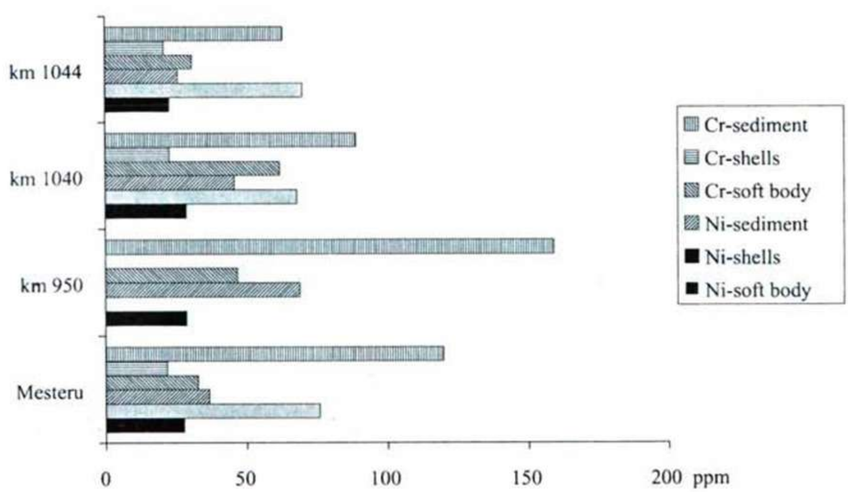

Fig. 4. Content of Ni and Cr in the soft bodies and in shells of *Unio pictorum* and in the upper thin layer of the sediments in Meşteru Lake and in the Danube River km 950, km 1040 and km 1044.6

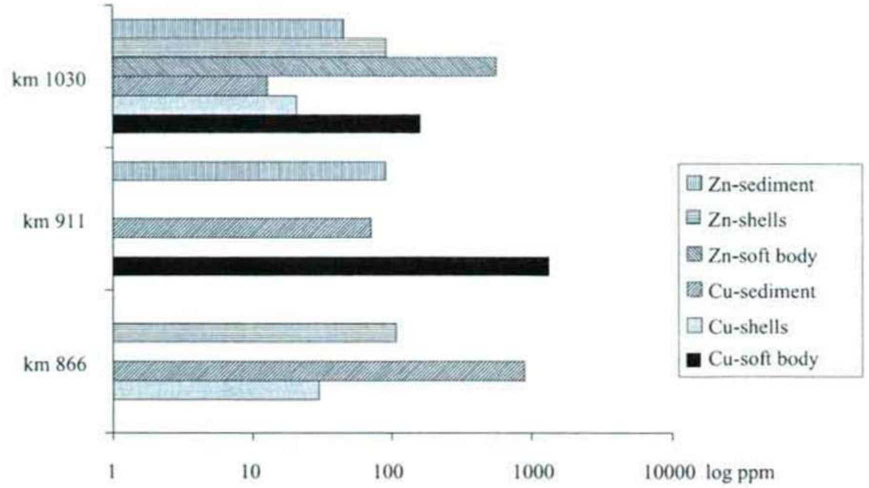

Fig. 5. Content of Cu and Zn in the soft bodies and the shells of *Unio tumidus* and in the upper thin layer of the sediments from the Danube River, km 866, km 911 and km 1030

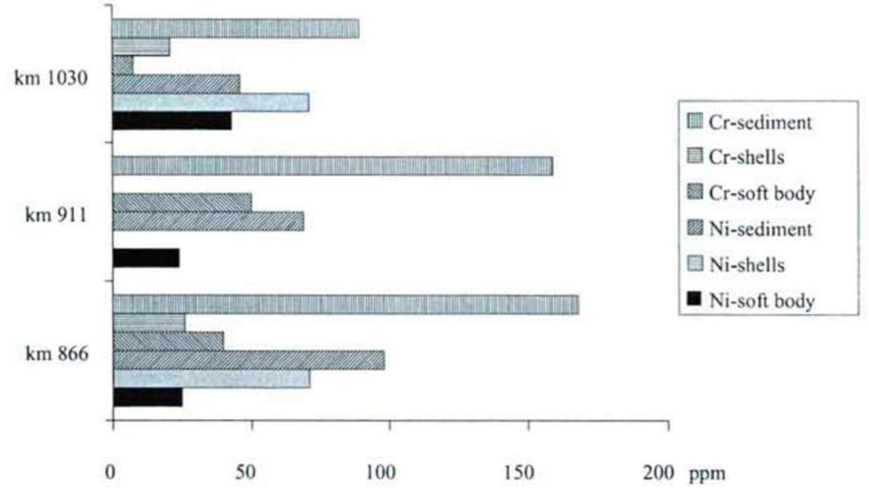

Fig. 6. Content of Ni and Cr in the soft bodies and shells of *Unio tumidus* and in the upper thin layer of the sediments in the Danube River, km 866, km 950 and km 1030

The same content in sediment is linked to higher values in the soft bodies in *U. pictorum*, less than *U. tumidus*, followed by *A. cygnaea,* while the content in shells are about the same. In the shells the content of Zn is higher than in sediments, and about in the same scale interval for all of the analysed species. With rare exceptions, the content of Cr in soft bodies is higher than in shells. In the same condition of sediments, the highest accumulation rate is showed by *U. pictorum,* followed by *A. cygnaea* and *U. tumidus.* In many cases the contents of the most hazardous metals are above the safety limits for these organisms, proving that heavy metals are a serious danger for the future, both for naiads and their environment.

Conclusions

Although most areas of the Danube Delta Biosphere Reserve are in a good ecological condition, the age structure, the ratio of recently died individuals and the rarity of some unionacean species prove a certain degradation of the habitats. High values of heavy metals both in shells and soft bodies of these bivalves are also threat indices. Pollution and habitats degradation, although still not obvious, are among the future dangers that could affect the communities of this reserve.

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